UNITED STATES PATENT APPLICATION FOR:

SELF-ALIGNING COMPONENTS FOR ELECTROCHEMICAL CELLS

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SELF-ALIGNING COMPONENTS FOR ELECTROCHEMICAL CELLS

This application claims priority to U.S. Provisional Patent Application number 60/431,019 filed on December 4, 2002.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to method and apparatus for assembly of electrochemical cells and some assemblies for use in electrochemical cell stack.

Background of the Related Art

Electrochemical cells include, without limitation, phosphoric acid type cells, solid oxide type cells and proton exchange membrane (PEM) cells. Electrochemical cells based on PEM technology has attracted increasing interest for a variety of reasons, including the moderate operating conditions and the small component geometries that can be accomplished with the use of a proton exchange membrane. A PEM cell or stack of PEM cells comprise a number of generally planar components that collectively account for the functions of distributing reactant fluids and removing product streams from the cells. This is accomplished through manifold channels formed by the alignment of adjacent planar components having similar or identical manifold passages therein. The manifolds communicate with flow channels within the framing members to provide fluid communication with appropriate flow fields and the corresponding bonding electrodes.

In order to successfully assemble a modern PEM electrochemical cell or stack, it is necessary to have a number of precision-manufactured components, as well as procedures to assure that the appropriate components are assembled in the correct order, orientation, and alignment. The intricacy of the components combined with the large number of components, complicates the assembly and can lead to an improperly constructed cell.

Efforts to improve the alignment of cell components have lead to the wide spread use of jigs that allow each component to be properly aligned during assembly of the stack. Typically, a jig will provide either a structural member around the perimeter of the

components allowing the components to be stacked therebetween, or a rod or pin that is allowed to extend through open features common to each of the components, such as a manifold passage. Such jigs may be dedicated jigs for use in multiple assemblies or the jigs may be incorporated into the final electrochemical cell assembly in the form of tie rods.

Even with the use of modern jigs, it is possible to mistakenly invert components or place components in the stack in an improper order. Prevention of these mistakes is typically limited to the degree of attention given by the assembly operator. Detection of improper assembly can be accomplished through testing procedures performed following completion of the assembly. Furthermore, the complexity and number of the components requires a time-consuming assembly process and increases the possibility of damaging components.

Accordingly, there is a need for an improved method and apparatus for assembly of electrochemical cell components into cells and stacks. It would be desirable if the method and apparatus provided more accurate alignment of components with increased ease of assembly. It would also be desirable if the method and apparatus reduced the occurrence of improper orientation of components. It would be even more desirable if the method and apparatus could reduce the number of components that must be handled in a final assembly of an electrochemical cell or stack. In particular, it would be beneficial if the method and apparatus would maintain alignment of the components once they have been initially assembled.

SUMMARY OF THE INVENTION

The present invention provides an assembly for an electrochemical cell, comprising a plurality of self-aligning components or plates, each plate having at least one projection extending outward from the plane of the plate and at least one recess adapted to receive the ends of the projections of another plate. The depth of the recess should be sufficient to receive the projection without limiting compression of the plates.

Optionally, the projection and recess or cavity interlock to maintain the relative position of the plates. In one embodiment, the at least one recess is adapted to frictionally engage the ends of the projections of another plate. In another embodiment, the at least one projection is a plurality of projections positioned on the plates in a manner that will only interlock with the recesses of another of the plates if the relative orientation of the plates provides proper alignment of a plurality of manifolds in the plates. The orientation-specific arrangement can be achieved when the plurality of projections are not evenly spaced about the plates. In a further option, an adhesive may be disposed between two of the self-aligning plates.

The invention also provides for two or more of the self-aligning plates to be coupled within a subassembly. By contrast, a self-aligning plate of a first subassembly is coupled to a self-aligning plate of a second subassembly. Also, an intermediate plate may be disposed between the self-aligning plates and have at least one passageway through the plate for alignment with the at least one projection of an adjacent self-aligning plate. In a preferred embodiment, the self-aligning plates comprise interlocking frames.

The present invention also provides a bipolar plate assembly for an electrochemical cell, comprising a first interlocking plate having at least one projection extending outward from the plane of the first plate, a second interlocking plate having at least one recess adapted to receive the ends of the projections of the first plate, and a gas barrier disposed between the first and second interlocking plates and having at least one passageway through the barrier for alignment with the at least one projection of the first plate. Preferably, the first and second plates form flowfields. In an alternative embodiment, the second plate has at least one projection extending outward from the plane of the second plate, and the bipolar plate assembly further comprises a third interlocking plate having at least one recess adapted to receive each of the at least one projection from the second plate, and a second gas barrier disposed between the second and third interlocking plates and having at least one passageway through the second gas barrier for alignment with the at least one projection of the second plate. Preferably, the

first and third plates form reactant flowfields and the second plate forms a cooling fluid flowfield.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure **1** is a cross-sectional side view of a first planar component having a cavity formed therein and a second component having a projection extending there from.

Figure **2** is a cross-sectional side view of a second pair of interlocking components, including a first component having a projection and opposing cavity receiving a second component having a projection.

Figure **3** is a cross-sectional side view of a first planar component having a projection and opposing cavity align with a second component having a projection and cavity.

Figure **4** is a cross-sectional side view of interlocking plates with a cavity in the form of a hole and a second component having a projecting number extending the hole.

Figure **5** is a cross-sectional side view of components that interlock through the use of identical tab elements that allow the components to be snapped together.

Figure **6** is an expanded view of an electrochemical sub assembly referred to as fluid cooled bipolar plate.

Figure **7** is a schematic cross-sectional side view of the assembly of Figure **6**.

Figure **8** is a face on view of the frame shown in Figure **6** and Figure **7**.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a method and apparatus for assembling electrochemical cell components into cells, sub-stacks of cells and stacks of cells. The method involves securing one component relative to another component for the purpose of assembling the components into an electrochemical cell device. The method involves the steps, alone or in combination, of aligning two or more electrochemical cell components to insure proper functioning of the components, orienting two or more

electrochemical cell components in the proper relationship to insure proper functioning of the resulting electrochemical cell device, or integrating two or more electrochemical cell components into an integral structure that can be handled as a single unit.

The components of the present invention are unique in that they provide alignment of two or more components without introducing additional parts that would add to the component count or complexity of the assembly process. Rather, the present invention includes at least one component having an integral projection and at least one other component having an integral cavity for receiving the projection. The dimensions of the projection and cavity must allow the two components to mate without interfering with the face-to-face contact between the generally planar components. For example, the projections must generally be narrower or of the same dimension as the cavity so as to extend into, and to be received by, the cavity. Furthermore, the projection must not be taller than the cavity is deep after taken into account any intervening components or gaps. In order to provide alignment across the entire face of the components, it is preferred to have at least one component with a plurality of projections and at least one component having a plurality of cavities. It is also generally preferred that the projections and cavities be positioned at the generally opposite sides, end corners, and the like. Any number of projections and cavities may be used.

It is an important aspect of the components of the present invention that the self-aligning features, *i.e.,* the projections and cavities, are integral to the components so that part counts are not increased and the alignment is not subject to errors during assembly. It is preferred in accordance with the invention, that the self-aligning features of the components provide both the projection and the cavity necessary for aligning the components. For example, a component may have a projection extend from one face of the component, while the second face of the component is concave in the region behind the projection to form a cavity having a similar diameter.

Any number of components may be secured between two self-aligned components, although it is preferred that only very thin components be disposed between the self-aligned components. For example, a thin metal gas barrier or a membrane

electrode assembly may have alignment holes therein that are sized, shaped and positioned to be placed over or around a projection of an interlocking component in accordance with the present invention. By providing smaller component-to-component alignment features, it is possible to avoid the use of jigs, alignment pins, or rods to align the components. In this manner, the components provide an infinitely variable system that can align as few or as many components as desired and the size of the stack of components may be varied over time. It should be noted that even after using the interlocking components of the present invention to establish a sub-stack or sub-assembly, the resulting sub-stack or sub-assembly will similarly have projections on one terminal face and cavities on the opposing terminal face.

The nature of the interaction between a projection and mating cavity may vary in accordance with the situation. For example, and not by way of limitation, the projection may extend loosely into the cavity, press fit and secured under friction into the cavity, or snap fit into the cavity.

The projections and cavities of the components described above provide alignment of the components in an accurate and controlled manner without increasing part count and without threading long pins or rods through the components. In addition, the projections and cavities may be designed in a manner that also provides integration of the components into a single unit for purposes of further handling or assembling. For example, integration is accomplished where the interaction between the components is one of press fitting the projection into a cavity or snapping the projection into a cavity. The use of simple alignment pins does not provide this type of integration and the sub assembly must be handled carefully when removed from the pins to avoid moving the components out of proper alignment. By contrast, integration or interlocking of the components assures that the proper alignment will be maintained during further handling and assembly, as well as throughout operation of the electrochemical cell device.

In accordance with a further embodiment, the locations of the projections and cavities about the face of the components may be planned out in a manner that assures the proper orientation of the components. The term "orientation", as used herein, means that

the proper faces of the components are directed toward each other and also that the features on the components are in proper radial alignment as well. For example, the mere use of alignment pins may insure good horizontal alignment, but may allow the components to be improperly rotated or installed upside down. In accordance with the present invention, the components can be made to be orientation-specific by using a non-symmetric placement of the projections and cavities. Accordingly, if two components are oriented improperly, then the projections and cavities will not align and will not allow interlocking of the components. It is preferred that the components only be allowed to interlock when the proper orientation is used. One exemplary method for providing non-symmetric positioning of the projections and cavities is to offset each projection and a cavity by distance or angle (θ) relative to a position that would be symmetric. For example, in a circular cell arrangement symmetric placement of the interlocking features would be provided by four projections at equal 90° angle positions. By moving two adjacent projections toward each other by a given angle (θ) and two other projections toward each other by the angle (θ) it is possible to prevent the misalignment of the manifolds resulting in blockage of fluid flow.

In an additional, but related, aspect of the invention, a component may be made orientation-specific along one axis, but not orientational-specific about another axis. For example, this may be accomplished by making certain projections extend from one face of the components while other projections extend from the opposite face of the same component. Proper selection of the orientation of the projections and cavities on the opposing faces thereof, can allow the component to be turned over and still interlock with an adjacent component. This aspect can be used to advantage, for example, in components that are flow field frames by allowing a frame of a single design to be utilized for both the anode and cathode flow field frame merely by placing the anode and cathode manifold and flow channels in a manner that when the frame is flipped over it provides the desired alignment.

Figure 1 is a cross-sectional side view of a first planar component **12** having a cavity **14** formed therein and a second component **16** having a projection **18** extending

therefrom. As shown, the projection and cavity are made to prevent misalignment or relative shifting of the two components from side to side.

Figure **2** is a cross-sectional side view of a second pair of interlocking components, including a first component **20** having a projection **22** and opposing cavity **24** receiving a second component **26** having a projection **28.**

Figure **3** is a cross-sectional side view of a first planar component **30** having a projection **32** and opposing cavity **34** aligned with a second component **36** having a projection **38** and cavity **39**. This design of projections and cavities is generally preferred over those of Figures **1** and **2** in that both components **30** and **36** have the same self-aligning feature with the same dimensions to allow any number of components to be aligned in a similar manner.

Figure **4** is a cross-sectional side view of a first component **40** with a cavity in the form of a hole **42** and a second component **44** having a projection **46** extending into the hole **42.**

Figure **5** is a cross-sectional side view of components **50** and **52** interlocked through the use of identical tab elements which allow the components to be snapped together. The tabbed components, referred to generally as **54,** include a ridge portion **56** for receiving the finger portion **58** from an adjacent tab **54**. Accordingly, snapping or interlocking these components requires no more effort than to press the two components together when they are properly aligned.

Figure **6** is an expanded view of an electrochemical sub assembly referred to as a fluid cooled bipolar plate **60**. The bipolar plate comprises three frames **62, 64, 66** having self-aligning features in accordance with Figure **3,** including projections **32** and cavities **34**. A first gas barrier plate **68** is disposed between frames **62** and **64** and is secured in proper alignment about the projection **32** of plate **62** and the cavity (not shown) that is behind projection **32** of plate **64.** An additional gas barrier plate **70** is positioned in a similar manner between frames **64** and **66**. The flow fields **72** are disposed within the open central regions of the frames **62, 64, 66.** Having two projections **32** and two cavities **34** on each side of the frames, as shown, allows for the dual use of a single frame to

establish the frame **62** and frame **66**. Since rotating frame **62** about a vertical axis provides the needed arrangement for the frame **66**.

Figure **7** provides a schematic cross-sectional side view of the assembly **60** of Figure **6**. Accordingly, the frames **62, 64, 66** are shown in alignment with projections **32** received within cavities **34** of adjacent frames. The gas separator plates **68, 70** are received within the respective frames, and the flow fields **72** are disposed within the open central region of each frame.

Figure **8** provides a face on view of the frame **62** shown in Figure **6** and Figure **7**. Accordingly, the frame **62** is shown having projections **32** on the right side of the front face and cavities **34** on the left hand side of the same face to prevent accidental rotation of the frame 90° out of alignment and to allow the frame to be re-used as anode and cathode frames by flipping the frame around the axis α. The two projections on the right are offset from 90° angles by the angle θ and the opposing cavities **34** are also offset from 90° by the angle θ. Accordingly, it can be seen that the frame **62** has the same exact front view as back view. Frame **62** is also shown with inlet and outlet manifold passages **80** for a first reactant gas stream and manifold passages and flow channels **82** for a second reactant fluid stream. The frame is also shown with optional fluid cooling inlet and outlet manifolds **84** which will only have flow channels in communication with the cooling fluid flow field of the fluid-cooled bipolar plate shown in Figure **6**.

It should be understood from the foregoing description that various modifications and changes may be made in the preferred embodiment of the present invention without departing from its true spirit. It is intended that this description is for purposes of illustration only and should not be construed in a limiting sense. The scope of this invention should be limited only by the language of the following claims.